Distribution, habitat and conservation status of the Green and Golden Bell Frog *Litoria aurea* (Lesson 1829) (Anura: Hylidae) in Victoria

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ABSTRACT

An overview of the distribution of *Litoria aurea* in Victoria is presented. Habitats in which the species has been recorded are described and its current conservation status is assessed. *Litoria aurea* is restricted to east Gippsland where it occurs predominantly at low altitudes along the coast and hinterland. The species is usually associated with stationary water bodies, mostly permanent, in both forested and cleared habitats. The species has also been found in a range of terrestrial habitats, often considerable distances from waterbodies; suggesting a high dispersive ability and importance of terrestrial habitats. Little evidence of a decline in the distribution or abundance of *L. aurea* was found based on comparisons of historical and recent information. Much of the habitat and range of the species was found to be secure within the region. Possible reasons for the apparent differences in population trends between New South Wales and Victoria are discussed.

INTRODUCTION

The Green and Golden Bell Frog *Litoria aurea* occurs along the eastern seaboard of Australia, from the far north coast of New South Wales to eastern Victoria, and inland on to the Southern Tablelands of New South Wales (Cogger 1992; Watson and Littlejohn 1985). The conservation status of this species has received considerable attention in New South Wales in recent years. Substantial population declines of *L. aurea* have been reported throughout New South Wales (Mahony 1993; Osborne 1990; Osborne *et al.* 1996; A. White, Australian Museum, pers. comm.). While populations still occur throughout the coastal portion of its range, the species has virtually disappeared from the Southern Tablelands of New South Wales and the Australian Capital Territory (Osborne 1990, 1992; Osborne *et al.* 1996). As a consequence, *L. aurea* has been listed as Threatened under Schedule 12 (endangered fauna) of the *NSW National Parks and Wildlife Act* (1992), and identified as endangered in the Australian Frog Action Plan (Tyler, in press). In contrast *L. aurea* is not listed as threatened in Victoria (CNR 1995).

Reasons for the observed declines of *L. aurea* in New South Wales are not clear. Introduction of Mosquito Fish *Gambusia holbrooki* and destruction and modification of wetlands have been implicated (White and Pyke 1996; Morgan and Buttemer 1996). However, the species has been noted for its ability to persist in substantially modified or disturbed areas (Osborne 1990; A. White, pers. comm.; G. Gillespie, pers. obs.), which has confounded any clear determination of what may constitute critical habitat and the causes of the apparent decline of the species. The current distribution and abundance on the south-east coast of New South Wales and in eastern Victoria has so far received little attention in discussions of the plight of this species. A clear picture of the relative abundance and habitat use throughout the entire range of the species is necessary to fully ascertain its conservation status and determine the full range of habitats which are utilized, particularly unmodified habitats. This is an important prerequisite for determining what constitutes critical habitat for the species, and for gaining a full understanding of the causes of decline and how to ameliorate them. In this paper I present an overview of the distribution of *L. aurea* in Victoria, describe habitats in which it has been recorded, and assess its current conservation status in that state.

METHODS

Information on the historical (pre-1980) occurrence of *L. aurea* in Victoria was gathered from the National Museum of Victoria, literature accounts (Lucas 1892; Copland 1957; Littlejohn 1963; Littlejohn *et al.* 1969; Norris *et al.* 1983) and field notes of Murray Littlejohn and Graeme Watson (University of Melbourne) and Peter Robertson (CNR, Heidelberg, Victoria). This was supplemented by a study conducted by Sherwin (1978) that provides a detailed account of the western range limit of *L. aurea* in Victoria. Brook (1982) provides a summary of the distribution of *L. aurea* based on much of this information.

Since 1980, the Gippsland area of Victoria has been the subject of extensive faunal survey. These investigations have included broad-scale regional survey (Norris *et al.* 1983; LCC 1985; Victorian Wildlife Atlas) and numerous forest management block surveys (Chesterfield *et al.* 1983; Carr *et al.* 1984; Horrocks *et al.* 1984; Opie *et al.* 1984; Brown *et al.* 1986; Cherry *et al.* 1986; Brown *et al.* 1987; Horrocks *et al.* 1987; Macfarlane *et al.* 1987; Yugovic *et al.* 1987; Chesterfield *et al.* 1988; Henry *et al.* 1988; Earl *et al.* 1989; Opie *et al.* 1990; Westaway *et al.* 1990a,b; Lobert *et al.* 1991; Loyn *et al.* 1992; Peacock *et al.* 1992; Gillespie *et al.* 1992). Nine other unpublished surveys have been conducted in East Gippsland by CNR and the data are included in the Victorian Wildlife Atlas. These surveys have provided much of the available knowledge on distribution and habitat occurrence of *L. aurea* since 1980. These data have also been supplemented by the author's incidental observations and those of other biologists (Jeanette Kemp, Townsville, Queensland, pers. comm.; Harry Hines, NSW National Parks and Wildlife Service, Armidale, pers. comm.; Barbara Triggs, Dead Finish, Victoria, pers. comm.).

Trends of populations of *L. aurea* in Victoria were examined firstly by comparing the range of the species as is currently known (based on post-1990 records) with the historical known range (pre-1980 records). No rigorous quantitative data have been collected on the relative abundance of *L. aurea* over time at any sites. Survey effort throughout the range of the species is also inconsistent over time. Therefore, no rigorous assessment of changes in population size or local patterns of distribution are possible, except where the species has disappeared from known localities. To assess any broad changes in relative abundance over time, the relative proportions of records of different numbers of frogs detected were compared across different time periods. A chi-squared test was used to assess differences in the relative proportions of records of individual frogs, 2–10, 11–100 and over 100 individuals across three time periods, pre-1980, 1980–1989 and 1990–present. The rationale of this approach is that over a broad period of time the detection rates of single and multiple frogs should remain broadly similar, despite differences in sampling effort unless there is a substantial change in the overall abundance of the species.

The current conservation status of *L. aurea* in Victoria was assessed by examining potential threats to known habitat within the range of the species. Representation of the species in the current reserve system was also evaluated.

RESULTS AND DISCUSSION

General Distribution

The distribution of *L. aurea* in Victoria is restricted to East Gippsland and extends from the eastern border with New South Wales to Lake Wellington, near Bairnsdale (Fig. 1). There is a contact zone with *L. raniformis* between the Lake Wellington area and the Brodribb River, in which intermediate forms have been recorded (Sherwin 1978). Within this area positive identification of taxa is not always possible. The disjunction in the distribution south-west of Mallacoota probably reflects a lack of field sampling, due to limited access into this area.

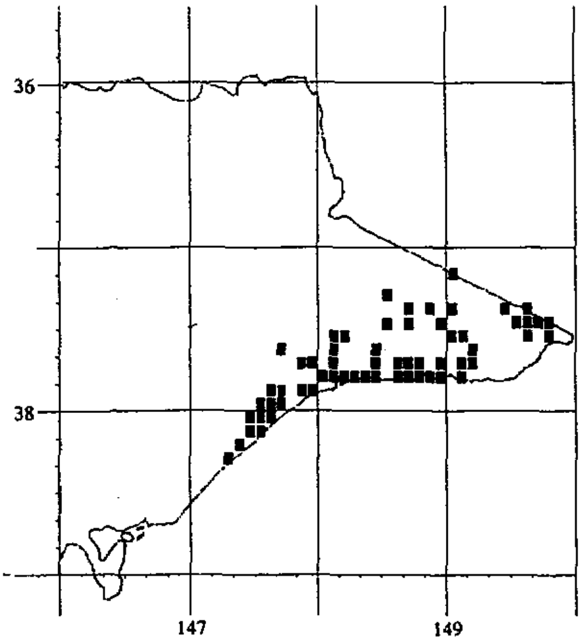


Fig. 1. Distribution of 5 × 5 minute grids in which *Litoria aurea* has been recorded in Victoria. (Note: Each cell may contain more than one record.) Source: Atlas of Victorian Wildlife; Brook 1982; Brown *et al.* 1987; Earl *et al.* 1989.

East Gippsland comprises a diversity of landforms that range through coastal dunes and plains to dissected foothills, and a hinterland that rises to over 1 400 m, with a variety of intermontane basins and montane plateaux. Unlike the rest of Victoria, the climate is subjected to a strong easterly influence. Rainfall is spread evenly throughout the year and ranges from less than 700 mm in the rain shadow country of the upper Snowy River to 2 000 mm on the Errinundra Plateau in the centre of the region. The average rainfall is in the range of 900–1 000 mm (Woodgate *et al.* 1993). The region remains predominantly forested, with clearing for agriculture being restricted largely to coastal plains in the Gippsland Lakes area. Other areas of clearance are restricted to terraces of the Snowy, Brodribb, Cann and Genoa Rivers, and the southern margins of the Monaro Tablelands and fringing hills along the New South Wales border.

Litoria aurea is found predominantly on the coastal plains and low foothills of the hinterland

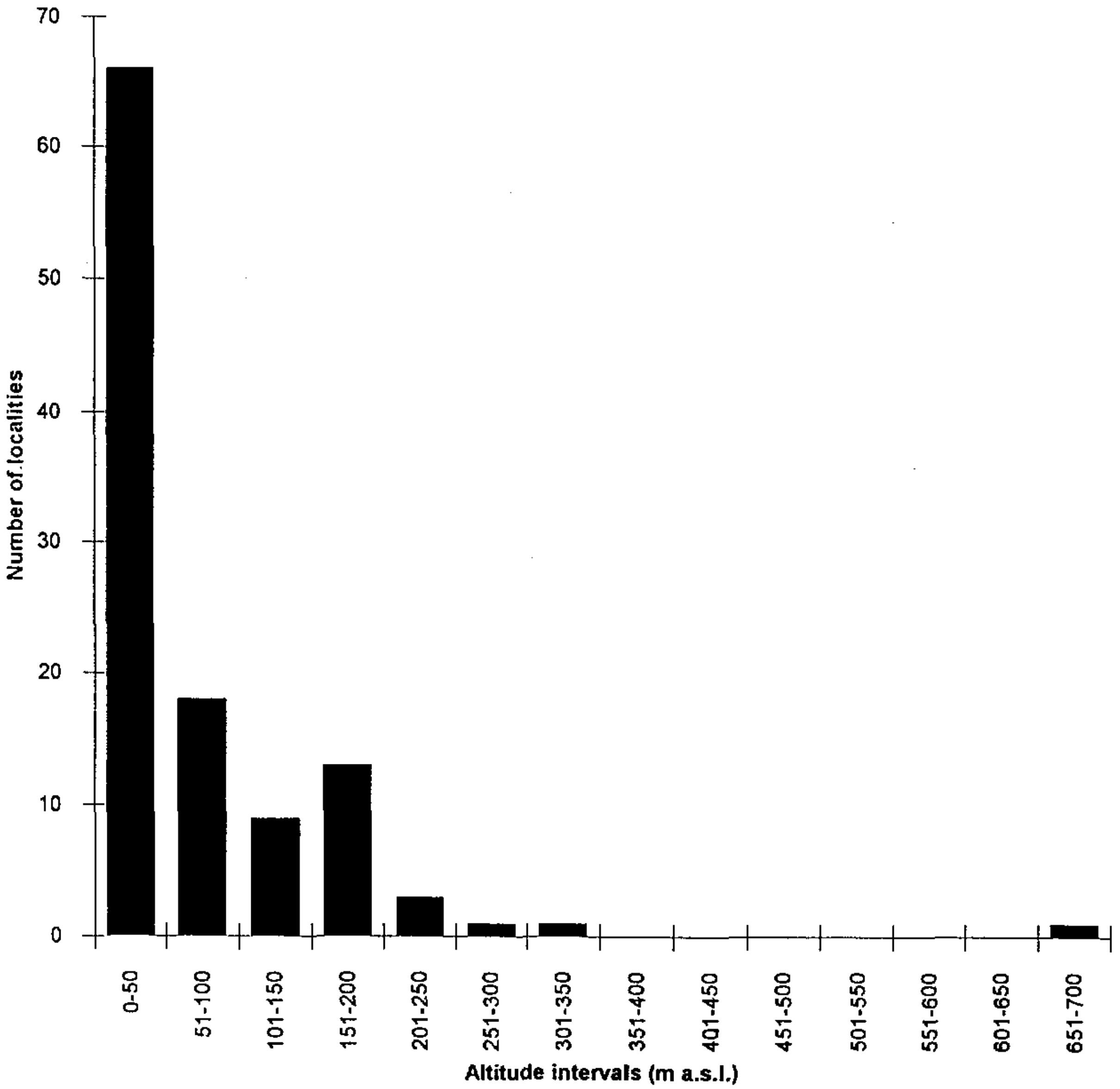


Fig. 2. Altitudinal distribution of records of *Litoria aurea* in Victoria.

although populations also occur inland along terraces of the Brodribb, Cann and Genoa Rivers. At the western extremity of its range it is restricted to the coastal fringe. Most records have been from near the coast below 50 m a.s.l. Records of *L. aurea* drop off sharply above 200 m a.s.l. (Fig. 2). The number of records of *L. aurea* also diminishes away from the coast which may reflect a progressive rise in altitude. With the exception of one record at 670 m near Yalmy Road, all other inland records indicated in Figure 1 are along major river valleys.

Brook (1982) documents a record of *L. aurea* from the southern Monaro Tablelands near Bendoc. The precise locality is unknown but is at least 800 m a.s.l. However, the taxonomic identity of this record is uncertain. The record originates from a field observation; no specimen was collected and no call recording was made. *Litoria aurea* has not been recorded in this region of New South Wales (Osborne *et al.* 1995; Thompson *et al.* 1995). *Litoria raniformis* has been collected from this area (Museum of Victoria records) and call data collected by Murray Littlejohn, University of Melbourne (pers. comm.) suggests that *Litoria flavipunctata* (Courtice and Grigg 1975) may also have occurred there. The morphological similarities of this group may make field identification difficult in the absence of call data, particularly given the potential for hybridization between taxa. Further doubt is cast on the existence of *L. aurea* in this area by the disparity between the environment there and that of the general distribution of *L. aurea* in East Gippsland. The species is restricted to warm temperate environments while the southern edge of the Monaro Tablelands is cold temperate, comprising wet montane and sub-alpine environments.

Habitat

Litoria aurea has been recorded in a range of lentic and terrestrial habitats in Victoria. Breeding activity, by way of calling or presence of larvae, has been documented from dams in both forested and cleared areas, swamps in farmland, gravel pits (Brown *et al.* 1987), billabongs (G. Gillespie, pers. obs.), marshes, coastal lagoon wetlands (H. Hines, pers. obs.; G. Gillespie, pers. obs.), wet swale herblands (J. Kemp, pers. comm.; G. Gillespie, pers. obs.), isolated streamside pools (G. Gillespie, pers. obs.). These habitats are mostly permanent but include some ephemeral water bodies. Males have also been heard calling from amongst dense riparian scrub along still sections of streams (Gillespie, pers. obs.; P. Robertson, pers. comm.). All habitats are characterized by stationary water. Virtually all are isolated water bodies, free of native fish species. All sites observed by the author typically have dense emergent vegetation. At sites in pastoral areas this vegetation usually comprises *Juncus* spp. and other sedges, while in naturally vegetated areas *Melaleuca squarrosa* and *Gahnia* spp. dominate.

In Victoria *Litoria aurea* has been heard calling from mid-September to early January (Atlas of Victorian Wildlife; G. Gillespie, pers. obs.; B. Triggs, pers. comm.). Calling activity appears to be most intense on warm nights from late October to late December. Tadpoles (Gosner stage — late 30s) have been observed between February and April (G. Gillespie, pers. obs.).

In lowland areas of East Gippsland, permanent swamps, billabongs and temporarily inundated heathlands form an extensive mosaic of water bodies along the coastal plain. Much of these wetland habitats remain largely intact. The availability of these habitats diminishes inland due to the increased topographic relief. This change may be a major factor, apart from climatic differences, in largely excluding *L. aurea* from the more dissected hinterland, except along major water courses where billabongs and swamps occur. These areas are also warmer and have a lower rainfall.

Litoria aurea has been found in a diversity of terrestrial habitats including Lowland Forest (Gillespie *et al.* 1992), Banksia Woodland, Wet Heathland, Riparian Scrub Complex, Riparian Shrubland (G. Gillespie, pers. obs.), Riparian Forest (Earl *et al.* 1989), Damp Forest, Shrubby Dry Forest (G. Gillespie, pers. obs), Limestone Box Woodland (Atlas of Victorian Wildlife) and cleared pastoral areas (Brown *et al.* 1987; G. Gillespie, pers. obs.). Woodgate *et al.* (1993) provide definitions and descriptions of these ecological vegetation classes.

Riparian Scrub Complex, Riparian Shrubland and Riparian Forest usually occur along drainage gullies and riparian margins, Wet Heathland usually occupies the zone between Riparian Scrub and adjacent better-drained habitats (Woodgate *et al.* 1993). These habitats are therefore often proximal to aquatic environments favoured by *L. aurea.* In contrast, Lowland Forest and Banksia Woodland are widespread habitats occurring in better-drained areas. *Litoria aurea* has been recorded frequently on forest tracks in these habitats on wet nights; often over 1 km from any water bodies typically used by the species (G. Gillespie, pers. obs.). Isolated occurrences of *L. aurea* have been recorded on Shrubby Dry Forest ridges on wet nights and in Damp Forest several hundred metres from major drainage lines or other water bodies (G. Gillespie, pers. obs.). These observations indicate that *L. aurea* is relatively mobile and has the potential to forage and disperse over large areas away from aquatic environments. The importance of dispersal and terrestrial habitats to maintenance of populations is unknown, but it suggests that assessments of habitat requirements of *L. aurea* need to incorporate examination of a broader range of criteria beyond just aquatic habitats.

Population Trends and Conservation Status

Despite the relative intense survey history of the Gippsland area over the past 13 years, there is virtually no quantitative data on populations of *L. aurea* over any time period which would allow an assessment of population trends. These faunal surveys, as with most other general surveys conducted in Australia, deal poorly with amphibians. Frogs generally have episodic activity patterns, patchy distributions across the landscape, and are otherwise cryptic by nature. Hylids generally cannot be trapped, so active searching techniques are required to quantify numbers. Intensive and repeated surveys are therefore required to gain any realistic assessment of relative abundance and distribution. Surveys conducted in East Gippsland were often of short duration (2–4 weeks) and were conducted in different areas in different seasons and years. The data on amphibians from these surveys, for the most part, provide only once-off, presence-only information. In view of this, it is not possible to assess any changes in the status of populations of *L. aurea* in Victoria with any rigour. However, several broad trends can be discerned from the extensive survey and incidental data collected in the region.

Comparisons of the known occurrence of *L. aurea* in Victoria between different time periods suggests that there has been no discernible change in the range of the species from historical (pre-1980) times to that detected during the past five years (Fig. 3). The relative paucity of records during the 1980's probably reflects the low survey effort in the core range of *L. aurea.*

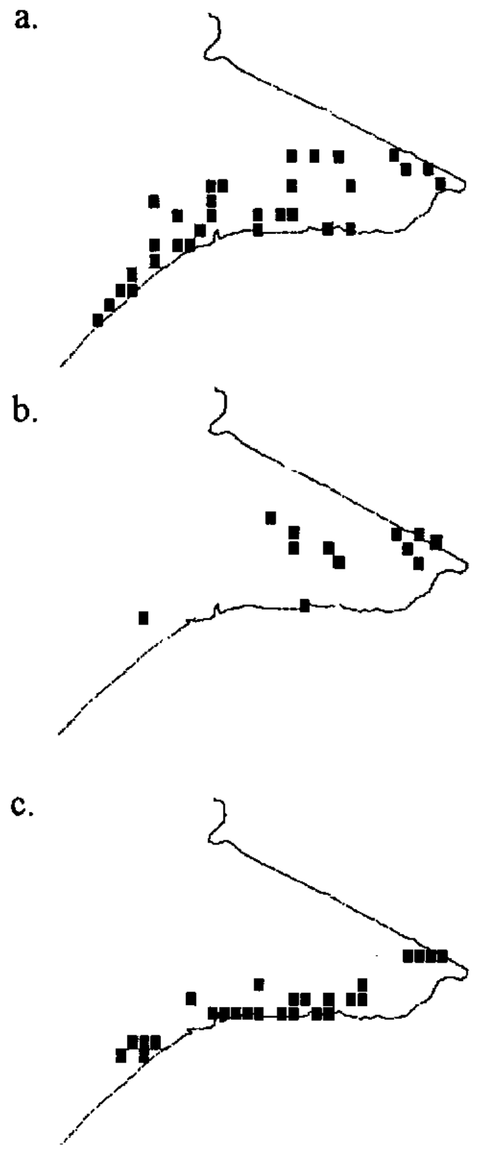


Fig. 3. Distribution of 5 × 5 minute grid records of *Litoria aurea* in Victoria during different time periods: (a) prior to 1980, (b) 1980–1989, and (c) 1990 to present.

In contrast, surveys since 1990 were conducted in coastal and lowland areas.

Figure 4 shows that *L. aurea* was detected much more frequently during the past five years, with over 70 records. This increase in sightings may be largely an artefact of the high survey effort across lowland parts of the region; however, several other species known from the region were detected much less frequently (e.g., Giant Burrowing Frog *Heleioporus australiacus*, Large Brown Tree Frog *Litoria littlejohni* and Martins Toadlet *Uperoleia martini*) or not at all (e.g., Southern Barred Frog *Mixophyes balbus*) (Atlas of Victorian Wildlife).

Estimates of the number of frogs present at a site vary widely. Mostly single individuals have been detected but records of up to 10 individuals are not uncommon. There are very few records of larger aggregations, with only one report of over 100 individuals. This was an estimate of several hundred males calling from swamp land near Sydenham Inlet (H. Hines, pers. comm.). Large aggregations (<100 individuals) have also been observed on the Snowy River flood plains and Wet Swale Herblands along the coast in Ewings Marsh Flora Reserve (G. Gillespie, pers. obs.). There are also few reports of large aggregations of *L. aurea* (>10 individuals) from prior to 1980 (M. Littlejohn, pers. comm; G. Watson, pers. comm.; Sherwin 1978). Comparison of the relative proportions of numbers of frogs detected per record (Fig. 4) show no significant difference across time periods ($\chi^2 = 4.359$, d.f. $= 6$, $P > 0.05$). This does not account for differing sampling intensities, sampling technique or surveyor differences. Data on numbers of frogs present at pre-1980 sites are likely to be conservative because they are based largely on museum records of numbers collected rather than those observed. These factors may weaken the comparison somewhat, nevertheless the high similarity between time periods does suggest that the relative abundance of *L. aurea* has not changed substantially during the past 20 years. These data also suggest that, in contrast to the historic situation in New South Wales (A. White, pers. comm.), large aggregations of *L. aurea* are atypical in Victoria.

Two reports of local disappearances of *L. aurea* have been received from East Gippsland. A *Litoria aurea* complex population known from East Lakes Entrance was last observed in the late 1960s (B. Peel, Flora and Fauna Branch, CNR, pers. comm.). This locality has been completely modified by urban development. A population of *L. aurea* disappeared from a swamp north of Mallacoota after the 1982/83 drought, during which the swamp dried up. However, the species recently recolonized the swamp (B. Triggs, Dead Finish, Mallacoota, Victoria, pers. comm.). This is consistent with observations of several other species suffering severe population reductions in Victoria at this time, such as the Southern Brown Tree Frog *Litoria ewingii* (M. Littlejohn, University of Melbourne, pers. comm.) and Growling Grass Frog *L. raniformis* (P. Robertson, Flora and Fauna Branch, CNR, Heidelberg, pers. comm.).

Potentially threatening processes for *L. aurea* in East Gippsland are relatively few compared with many areas in New South Wales, largely due to the very low human population in the area. Most of the region remains naturally vegetated. Pastoral areas comprise relatively small patches within a forest landscape, rather than the reverse. Therefore impacts from agricultural run off and human settlement are minimal. Although timber harvesting occurs extensively in the region, this practice may not

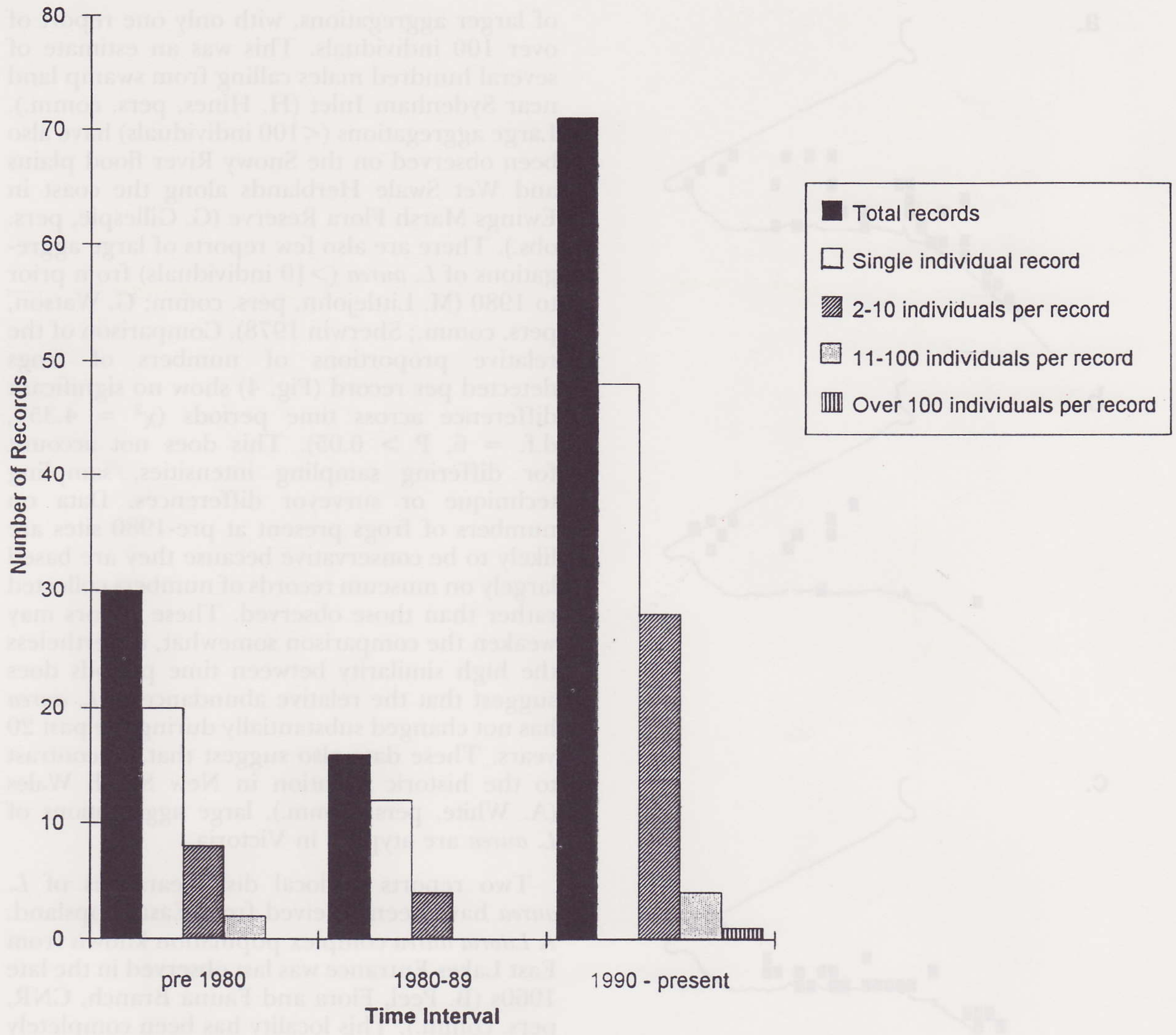
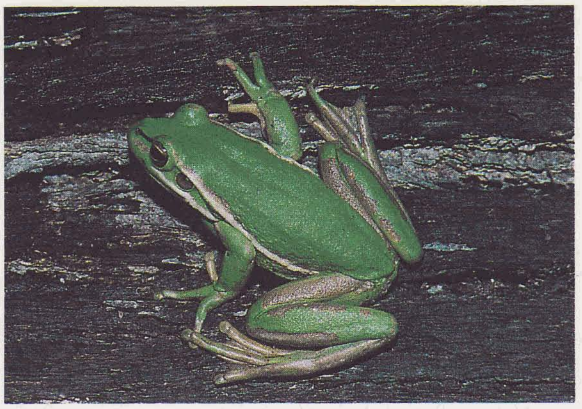


Fig. 4. Total numbers of records of *Litoria aurea* and proportions of abundance classes during different time periods.

significantly adversely affect *L. aurea*, due to its ability to persist in significantly modified habitats, and its mobility and potential to recolonize. In addition, a large portion of the range of the species is within either the Croajingalong National Park or other coastal reserves. In the absence of any evidence of decline, the species is therefore considered secure in Victoria (CNR 1995).

CONCLUSIONS

The population trends of *L. aurea* in New South Wales are not reflected in East Gippsland. There is no compelling evidence of a substantial decline and the species appears to occur in relatively low numbers compared with historical accounts from the east coast. There are several differences between East Gippsland and the east coast of New South Wales which may explain these differences. Most of East Gippsland remains largely undisturbed with a low human population. The mosaic of wetlands throughout the lowlands and coastal fringes remain relatively intact except at the western limit of distribution of the species. In contrast the natural vegetation of many areas of the east coast is much more fragmented, and water bodies suitable for breeding are reduced in number and quality. These two factors may significantly increase the distance between suitable breeding and refuge habitats and thus reduce the dispersal and colonization ability of the species. This would be further exacerbated by the urbanization and road infrastructure. Small, isolated populations would then be more vulnerable to local extinction due to environmental stochastic events, such as drought, and would be less likely to be recolonized. Larger populations would be similarly vulnerable if these events are severe enough or if the breeding habitats are unstable. Under this model, the populations that are most likely to survive are those that were largest in the first place and that have the most reliable breeding habitat through time.



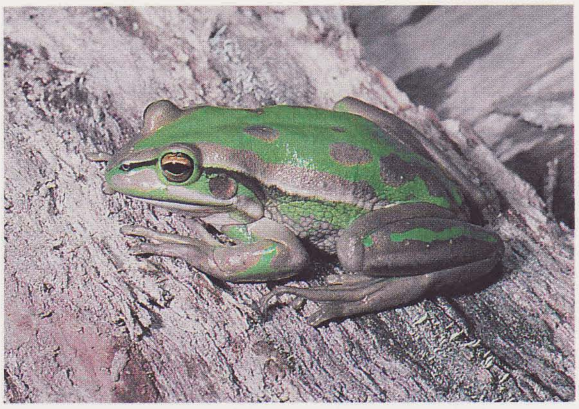


Plate 3a (top left). *Litoria aurea*, Genoa Peak Road, East Gippsland, Victoria. Note the plain green dorsal colour. Photo: G. Gillespie.

Plate 3b (top right). *Litoria aurea*, Bonang Highway, East Gippsland, Victoria. Note the green and brown dorsal pattern. Photo: G. Gillespie.

Plate 3c (bottom left). *Litoria aurea* breeding habitat, Cabbage Tree Lagoon, East Gippsland, Victoria.

The relatively intact landscape of East Gippsland may provide a greater continuity of habitat with a higher density of breeding or refuge areas. The potential for dispersal and recolonization after unfavourable disturbances therefore remains high. In addition, apart from isolated occurrences in farm dams, the Mosquito Fish *Gambusia holbrooki* is absent from the region east of the Snowy River in Victoria. This species has the potential to substantially increase mortality of *L. aurea* tadpoles (L. Morgan, Honours Thesis in prep.). Its absence may mean that a greater range of aquatic habitats remain suitable for reproduction for *L. aurea*, more colonies can persist in a given area and the distribution is less patchy. Although *L. aurea* is known to persist in cleared or otherwise highly modified areas, the availability of natural vegetation my still increase dispersal and foraging ability and may also ameliorate the impacts of environmental stresses, such as droughts and fires, or predation, by providing refuge areas. In the environment of East Gippsland, local stability of breeding and refuge habitat may be far less important to the persistence of the species compared with areas in New South Wales, due to the greater availability of habitat and the ability to disperse and recolonize.

East Gippsland provides an opportunity to study factors influencing habitat use and population dynamics of *L. aurea* in an area where populations of the species have persisted, rather than declined. An understanding of the roll of landscape factors, such as natural vegetation patterns, spatial and temporal distribution of available aquatic habitats and disturbance regimes, is likely to be important in determining processes limiting the distribution and abundance of the species. Examination of local habitat and landscape differences between areas of New South Wales where declines have occurred and East Gippsland should be an important component in the development of management plans to protect remaining populations in New South Wales.

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